Sborník vědeckých prací Vysoké školy báňské - Technické univerzity Ostrava
číslo 3, rok 2009, ročník LII, řada hutnická,
článek č. 1565

Dana SUCHÁ[1], Alena VAVROVÁ[1], Ján VAVRO[1] jr., Ján VAVRO[1], Pavel KOŠTIAL[2]

THE COMPARISON OF NATURAL'S FREQUENCY OF SOME MATERIALS BY THE HELP MODAL ANALYSIS

POROVNANIE VLASTNÝCH FREKVENCIÍ VYBRANÝCH MATERIÁLOV POMOCOU MODÁLNEJ ANALÝZY

[1] *Alexander Dubček University of Trenčín, Faculty of Industrial Technologies, Púchov*
[2] *VŠB - Technical University of Ostrava, Faculty of Metallurgy and Materials Engineering, Ostrava*

Abstract

Each object has its own resonant frequency. To the non problematic use of materials and equipment, it is necessary to accurately determine these frequencies. It is hard to imagine in today's multi' materials age epoch get by only using metal materials, however they are still important part of our daily life. In this article we identify own frequencies not only metal, but non-metallic materials too, namely the laminates and ceramic materials. In this case we use some special methods, we will deal with tests by the modal hammer with system PULSE. In this work are compared experimental own frequencies with numerical values for these materials. The numerical values we were calculated by the help software COSMOS M.

Abstrakt

Každý predmet má vlastnú rezonančnú frekvenciu. Pre bezproblémové používanie materiálov a zariadení je dôležité presne určiť tieto frekvencie. V dnešnej multi-materiálovej dobe sa však už nezaobídeme len z použitím kovových materiálov, aj keď tieto stále zostávajú dôležitou súčasťou nášho každodenného života. V tomto článku sa zaoberáme identifikáciou vlastných frekvencií kovových aj nekovových materiálov, konkrétne ide o lamináty a keramické materiály. Na toto je určených niekoľko špeciálnych metód, budeme sa zaoberať jednou z nich, testy modálnym kladivkom so systémom PULSE. V práci sú porovnané vlastné frekvencie pre jednotlivé materiály, určené teoretickým aj experimentálnym prístupom. Numerické hodnoty boli vypočítané pomocou softweru COSMOS M.

Key words: resonant frequency, laminates, ceramic materials

1. Introduction

There are two general cases-free oscillations and forced. The free oscillations as in the case that the oscillation under the action of forces that causes the system itself, in the absence of external forces. System under the action of free vibrations will oscillate in one or more of their frequencies, which is characteristic of a dynamic system of fixed mass and stiffness. Oscillations which are excited by using external forces called forced oscillations. If the vibrations give rise system that is forced to oscillate in the driving frequencies. [7]

Investigation of their frequencies is of importance particularly when assessing the conduct of the modeling object. These are mainly the fact that a significant frequency of excitation and the frequency of their own were the same, respectively. were sufficiently far apart. Otherwise, there is excited own oscillations, which is characterized by the so-called. resonant phenomenon, which is unacceptable in practice. [6] When the excitation frequency coincides with any of the frequencies of its own system to meet the conditions of resonance which leads to dangerous fluctuations. Then calculate their frequencies have a great importance in the study of vibrations. [8]

2. Principles of solution

Any physical structure can be modeled as a number of springs, masses, and dampers. Dampers absorb energy, but springs and masses do not. A spring and a mass interact with one another to form a system that resonates at their characteristic natural frequency. If energy is applied to a spring-mass system, it will vibrate at its natural frequency, and the level of the vibration depends on the strength of the energy source as well as the absorption or damping inherent in the system. The natural frequency of an undamped spring-mass system is given by the following equation [4]:

$$F_n = \frac{1}{2\pi}\sqrt{\frac{k}{m}} \qquad (1)$$

where Fn is the natural frequency, k is the spring constant, or stiffness and m is the mass. From this, it is seen that if the stiffness increases, the natural frequency also increases, and if the mass increases, the natural frequency decreases. If the system has damping, which all physical systems do, its natural frequency is a little lower, and depends on the amount of damping. If the damping is small, they have very little effect on the natural frequency of the system, so then it is possible to calculate those frequency of neglect own damping of system [4,7].

FEM

Finite element method become inevitable tool for analyses structures [2]. Its principle rests in discraditation linear continuum to certain (final) of the number of elements, whereby detect parameters are designed for individual nodal points [3].

3. Analysis model and results calculation

With using program system COSMOS version 2.75 were resolved natural frequencies on a few chosen materials (ceramics, laminate and steel, properties those materials are in Table 1 for free and constrained condition. Measurements designs for individual materials are showed in Table 2.

Tile from ceramic material was simulated by the help 4- mode tetrahedral solid element (TETRA 4). Model of design for free condition (Fig. 1) consisted of 134785 elements, which are situated of 31673 points. Size of edge element is max. 2 mm.

Model of design for constrained condition (Fig. 2) consisted of 159657 elements, which are situated of 35107 points. Size of element is max. 2 mm. Table 1 contains 7 computed natural frequencies for free and constrained condition.

Fig. 1 Free condition of ceramic design, analysis model

Fig. 2 Constrained condition of ceramic design, analysis model

materials	ceramics	
Frequency number	Free condition	Constrained condition
1.	34.04	127.7
2.	447.9	298.8
3.	543.9	449.3
4.	959	526.5
5.	1059	643.1
6.	1173	770.3
7.	1209	887.9

Table 1 Computed natural frequencies of ceramic material

Fig. 3 Free condition of laminated design, analysis model

Fig. 4 Constrained condition of laminated design, analysis model

Table 2 Computed natural frequencies of laminated material

materials	laminates	
Frequency number	Free condition	Constrained condition
1.	18.23	48.25
2.	59	57.14
3.	217.58	254.21
4.	269.3	305.13
5.	337	492.13
6.	536.27	748.28

Laminated design consisted of sixth segments of carbonaceous textiles and epoxy resin. It was simulated by the help SHELL4L . Model of design for free condition (Fig. 3) consisted of 199400 elements, which are situated of 117632 points, size of edge element is max. 2.5 mm.

Model of design for constrained condition (Fig. 4) consisted of 201600 elements, which are situated of 120771 points. Size of element is max. 2.5 mm. In computated model in a program COSMOS was used method Subspace iteration. Table 2 conteins 6 computed natural frequencies for free and constrained condition.

Design of *steel material* was simulated by the help - mode tetrahedral solid element (TETRA 4). Model of design for free condition (Fig. 5) consisted of 34284 elements, which are situated of 9148 points, max. size of edge element is 2 mm.

Model of design for constrained condition (Fig. 6) consisted of 25762 elements, which are situated of 7792 points. Size of element is max. 2 mm. Table 3 conteins 5 computed natural frequencies for free and constrained condition.

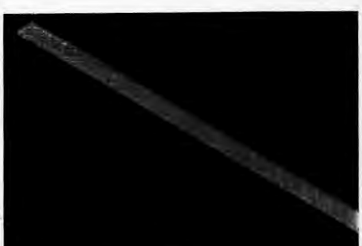

Fig. 5 Free condition of design of steel material, analysis model

Fig 6 constrained condition of design of steel material, analysis model

Table 3 Computed natural frequencies of design of steel material

material	Steel	
Number of frequency	Free condition	Constrained condition
1.	109.9	24
2.	302.1	135
3.	591.8	285.505
4.	977	602
5.	1458	969

Table 4 Properties of materials

Material	ceramics	laminate		steel
property		Epoxy matrix	Carbon fiber	
Elasticity modulus [MPa]	$110.40*10^5$	$1.5*10^5$	$4*10^5$	$2.06*10^{11}$
Density [kg/m^3]	1780	1180	1.5	7850
Poisson's ratio	0.22	0.25	0.28	0.3

Table 5 Proportion of specimen

Specimen proportion	Ceramics	Laminate	Steel
lenght [mm]	201.1	175	490
width [mm]	151.6	175	20
depth [mm]	5.4	1.8	5

4. Fundamental

Supporting the structure

The first step in setting up a structure for frequency response measurements is to consider the fixturing mechanism necessary to obtain the desired constraints (boundary conditions). This is a key step in the process as it affects the overall structural characteristics, particularly for subsequent analyses. [1]

Exciting the Structure

The next step in the measurement process involves selecting an excitation function (e.g., andom noise) along with an excitation system (e.g., a shaker) that best suits the application. The best choice of excitation function depends on several factors: available signal processing equipment, characteristics of the structure, general easurement considerations and, of course, the excitation system. The dynamics of the structure are also important in choosing the excitation function.

Testing by the use modal hammer

Although it is a relatively simple technique to implement, it's difficult to obtain consistent results. The convenience of this technique is attractive because it requires very little hardware and provides shorter measurement times.

Since the force is an impulse, the amplitude level of the energy applied to the structure is a function of the mass and the velocity of the hammer. This is due to the concept of linear momentum, which is defined as mass times velocity. The linear impulse is equal to the incremental change in the linear momentum. It is difficult though to control the velocity of the hammer, so the force level is usually controlled by varying the mass. Impact hammers are available in weights varying from a few ounces to several pounds. Also, mass can be added to or removed from most hammers, making them useful for testing objects of varying sizes and weights [1].

5. Experiment

On measuring natural frequencies, we used system PULSE, on the oscillation exciting impact hammer was used.

System PULSE 3560B (Fig. 7)

PULSE is a platform of a firm Brüel&Kjaer for the analysis noise and vibrtion. I tis a compact system for information obtaining..

Modal hammer type 8206-002 (Fig. 8)

This type of modal hammer was designed to excitation and measure shock forces applicated on a small and medium- size structures.

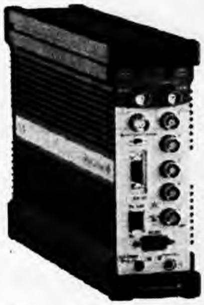

Fig. 7 Systém PULSE 3560B **Fig. 8** Modálne kladivko typ 8206-002

Natural frequency of all three materials specimen was measurement in free and in constrained condition (Fig. 9 – Fig. 14).

Fig. 9 Free condition of ceramic design, experimental measurement

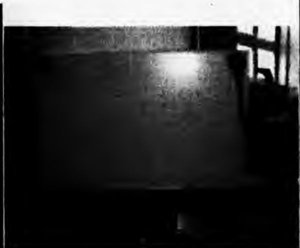

Fig. 10 Constrained condition of ceramic design, experimental measurement

materials	ceramics	
Frequency number	Free condition	Constrained condition
1.	32	122.66
2.	448	277.3
3.	544	440
4.	957.33	528
5.	1074.6	640
6.	1160	765.33
7.	1210.6	888

Table 6 Experimental measurement natural frequencies of ceramic material

Fig. 11 Free condition of laminated design, experimental measurement

Fig. 12 Constrained condition of laminated design, experimental measurement

materials	laminate	
Frequency number	Free condition	Constrained condition
1.	24	56
2.	56	248
3.	216	312
4.	280	504
5.	384	792
6.	520	960

Table 7 Experimental measurement natural frequencies of laminated material

materials	laminate	
Frequency number	Free condition	Constrained condition
1.	112	16
2.	304	104
3.	608	300
4.	1000	593.6
5.	1488	983.8

Fig. 13 Free condition of design of steel material, experimental measurement

Fig. 14 Constrained condition of design of steel material, experimental measurement

Table 8 Experimental measurement natural frequencies of design of steel material

6. Conclusion

This work deals with the natural frequencies of three materials. Naturals frequency of each materials depends on degree of freedom, in this work were use free condition (the structure was suspended on soft elastic cords) and the constrained conditions (the structure was securely fastened in a clamp).

Generally we can say that the structure supports by free condition have higher natural frequency as than structure support by the constrained condition.

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Reviewer: Prof. Ing. Miroslav Tvrdý, DrSc., VŠB – TU Ostrava